UNIVERSITI TEKNOLOGI MARA

NUMERICAL ANALYSIS OF PROTECTED AND UNPROTECTED CELLULAR STEEL BEAMS (CSB) AT ELEVATED TEMPERATURE

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of the requirements for the degree of
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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my. study and research.

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ABSTRACT

Cellular steel beams (CSB) is widely used in European country, especially in the United Kingdom (UK) and many other country in recent years. There is a need to introduce these types of beam structure in Malaysian construction industries due to its advantages compared to conventional beam structures. These advantages include appealing design, structural strength effectiveness and permits serviceability pipes to go through the main web section of the CSB. Additional concrete slab attached on top of the CSB increases its strength as load bearing element against external loading action onto the beam. Even though the interaction between the concrete slab and CSB to create a strong structural member, the beam strength and stiffness is slowly deteriorated when expose to fire exposure and external applied loading action. CSB is highly exposed to fire if the fire hazard does occur in any compartment in buildings. It is very crucial to evaluate the structural performance behaviour of the composite CSB under applied loading at elevated temperature. Several failure modes were triggered due to this scenario, namely vertical deflection, web-post buckling and Vierendeel bending failure. In this research, numerical models were developed by using general purpose of ABAQUS finite element program to predict the failure modes and temperature evolution along the CSB section at elevated temperature. From the outcome of numerical simulations, it was found that the FE models were tremendously sensitive when applying the applied vertical loading and boundary conditions onto the CSB. Parametric investigation was conducted into various factors that contribute to the failure modes of CSB at elevated temperature. These important factors include applying fire protection material, different geometrical section of the beam and the size of the web opening of beam. Applying fire protection material of intumescent coating does reducing the temperature evolution along the beam section. Therefore, in this current study, temperature distribution, vertical displacement, web-post buckling and Viereendeel bending failure were measured and predicted for the CSB at elevated temperature. The temperature distribution along the beam section were significantly reduced when applying intumescent coating surrounding the beam. It is was observed that between 20% to 30% temperature reduction were obtained for applied intumescent coating thickness between 0.5 mm to 1.5 mm. However, vertical displacement does not have a significant effect when applying intumescent coating even though the displacement there were slightly decreasing. In addition, the web-post buckling were slightly decreased (approximately between 0% to 10%) when adopting fire protection material under applied vertical loading action. In terms of Vierendeel bending failure mechanism, the CSB were able to sustain higher loads through Von Mises stress distribution (approximately between 0% to 10% stress increase) along the beam section. Similar behaviour when adopting intumescent coating thickness between 0.3 mm to 1.5 mm were obtained in terms of higher maximum stress and fracture stress. Longer period of fire exposure can be predicted before the beam fails due to these extreme conditions. From the results of this research, a new 'Addendum' can be produced and can be included together with current steel beam design guidelines (Malaysian Standards-MS). Engineers will be benefited from this new iteration design guidelines to be added in designing steel buildings by considering fire exposure apart from traditionally design procedures.

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